TECHNICAL NOTE

AN APPROACH FOR QUICK METHOD OF ESTIMATING PASSENGER AND AIRCRAFT DEMAND FOR FEEDER AIR SERVICES IN INDIA

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Abstract

The recent and the proposed entry of new airlines both in the 'no-frills' and in the "full service" categories has completely changed the aviation scenario in India. Obviously this explosive increase in capacity will have a profound effect on the economy of the airlines both in the short term as well as in the long-term period. A growth of over 25% per annum in passenger traffic may not be sustainable for long; thus galloping increase in capacity may result in mergers and strategic alliances of airlines on one side and closing down of some of the airlines on the other side. A point, which is to be noted is that, most of the new entrants also operate in the major trunk routes and serve the metros and the major cities. What appears to have not been tapped is the equally large potential in the regional and short haul sectors, which serve major, and small city pairs and also act as feeders to the major hubs.Realizing the importance of this, the government in its new civil aviation policy has given thrust to regional/ short-haul air travel. In this paper, an attempt is made to review the hierarchy of airline networks in India with respect to trunk, major and feeder routes. The air passenger traffic carried in terms of revenue passenger kilometers (RPK) is compared with upper class rail traffic. The present status of feeder airline services in India is outlined. It is pertinent to study the passenger traffic demand in these feeder routes as compared to upper class rail traffic as some percentage of upper class rail passengers are willing to shift to air travel due to marginal difference between airfare and upper class rail fare and time factor. The future RPKs are forecasted based on the actual RPKs data and the estimated RPKs of earlier market survey. A suitable aircraft size for airline operations in these feeder routes is arrived at based on existing air traffic data by a simplified approach from the basic principles of airline business. A macroscopic measure is used to determine the aircraft demand by assuming average block speed and utilization for each aircraft type. A sensitivity analysis was carried out for various levels of traffic growth keeping in view the sharp increase of air travel in recent years and further growth in air traffic fuelled by feeder sector as the hinterland opens up industry, services and tourism.

Keywords*: air network, feeder route, passenger demand, frequencies, load factor, fleet mix*

Introduction

Transportation is the backbone of any nation's economic development. Air transportation assumes importance as it cuts down the logistic costs and assures fast travel and speedy delivery of products. In the past, the market for air transportation was limited to long haul routes because of economy of scale involved. The entry of Air Deccan in 2003 and subsequent entry of other new low cost air carriers in India have created a lot of interest in short haul air transportation. The advent and future availability of small aircraft and associated infrastructure coupled with integration of better ground access system could offer air services for short range travel connecting the remote communities, which otherwise was limited.

One of the most important problems encountered by airlines is how to match transport facilities with passenger demand. Flight frequencies and departure times on routes in a network reflect the manner in which transport facilities and passenger demand are matched. These two issues depend on passenger flight demand, number and type of aircraft in the fleet, aircraft rotation in the network, airline crew, and the technical /fleet maintenance system.Flight frequencies and departure times are considered to be most

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important factors that determine passengers' choice of air transport in general and an airline in particular when other modes of transport are available (15, 16). In this paper, flight frequencies, estimated passenger flow in city pair, average block speed, aircraft utilization, and load factors (constrained by minimum and maximum values) are incorporated in determining a suitable aircraft size and total aircraft demand for serving the feeder air services in India.

Hierarchy of Airline Network In India

The airline network in India can generally be classified into three categories, namely,

- Trunk routes (connecting four major metropolitan cities viz., Delhi, Mumbai, Kolkata and Chennai),
- Major routes [connection between major metros and metros, between metros and metros, between metro and other cities (block distance greater than 500 km)], and
- Feeder routes [connectivity between major metro/metro/major city and low tier cities (block distance less than 500 km)].

The feeder routes are generally classified in the range of 100 to 500 km (this is only an indicative for the sake of convenient classification in the Indian context with exceptions like Bangalore-Chennai sector etc). As per the 2004 estimates based on DGCA data (Director General of Civil Aviation, India), Table-1 show the number of routes and the passengers carried and Table-2 represents the share of each route over the total passengers carried. Fig.1 shows the time-series trend in growth of passengers carried for the last five years (1).

The compound annual growth rate (CAGR) over this period for trunk, major and feeder routes are 10, 4, and 2 percent respectively.

The share of feeder routes over the last five years has marginally declined from 11 to 10 percent, whereas the trunk routes share has increased from 11 percent in 1999 to 14 percent in 2004.

Airport Statistics

The number of airports / aerodromes in India are 449 and out of these only 211 has ICAO/IATA ID (1, 3). The number of airports classified as operational for civilian purpose are 199 (44 percent of total). Out of these operational airports, 84 are managed by Airports Authority of India (AAI), 87 are under state/ private ownership and 28 are civil enclaves in defence airports. But it is surprising to note that only 65 airports (one third of total operational) are being used by scheduled flights.

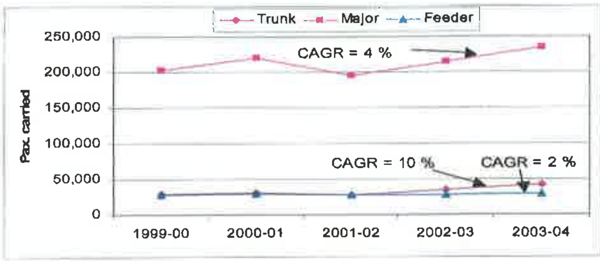

Fig.1 Trends in Growth of Passengers Carried

Table-1 : Hierarchy of Airline Network in India (Year 2004)

Route	Trunk Route	Major Route	Feeder Route	Total
Number of routes (per direction)	6	78	76	160
Passengers carried (per week per direction)	42,001	2,35,471	29,462	3,06,934
Percent of total traffic carried	13.7	76.7	9.6	100

Table-2 : Share of Passengers Carried by Three Categories of Routes

Sl. No.	Year	Trunk	Major	Feeder	Share (Trunk Routes)	Share (Major Routes)	Share (Feeder Routes)
1	1999-00	28,738	202,946	27,758	11.1%	78.2%	10.7%
2	2000-01	30,704	220,094	29,718	10.9%	78.5%	10.6%
3	2001-02	28,206	195,236	27,262	11.3%	77.9%	10.9%
4	2002-03	34,590	215,092	28,246	12.4%	77.4%	10.2%
5	2003-04	42,001	235,471	29,462	13.7%	76.7%	9.6%

Air Passenger Traffic in India

Based on the preliminary examination of published schedules of three airlines (Indian Airlines, Jet Airways, and erstwhile Air Sahara) in India and the DGCA airport statistics, around 65 cities are connected by air. The population of each city, its classification as major city (classified as A class /tier-I city in India: Table-3) and the total passengers handled along with embarked load factors are presented in Figs.2 to 6 (1, 4). Classification of cities merely allows the pattern to be viewed in one more dimension.

Table-3 : Classification of Cities

Class	Population
A*	> 1 million
B	500,000 to 1 million
C	100,000 to 500,000
D	50,000 to 100,000
E	20,000 to 50,000
F	10,00 to 20,000
G	< 10,000

* include the 4 major metros

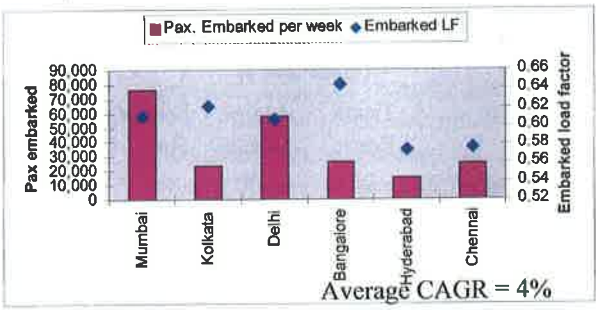

Fig.2 Passengers Embarked and ELF for Major Metro (Class A) Cities

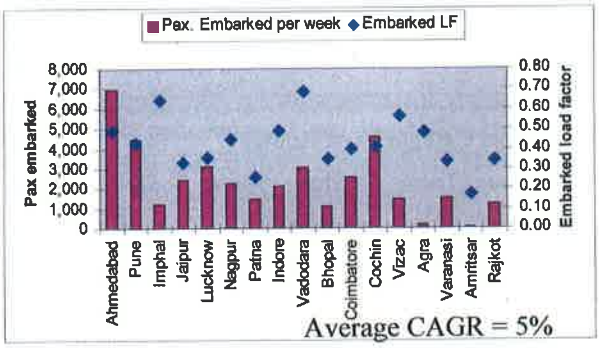

Fig.3 Passengers Embarked and ELF for Metro (Class A) Cities

Analysis of the data clearly shows that all State head quarters are connected. Where there is economic activity, tourism or if a destination has religious importance, there appears to be connection in addition to DGCA route dispersal guidelines. Population of the cities by themselves is not a condition for it to be connected. Historically,

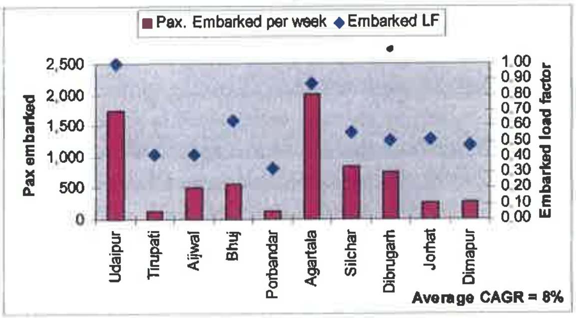

Fig.4 Passengers Embarked and ELF for Class B Cities

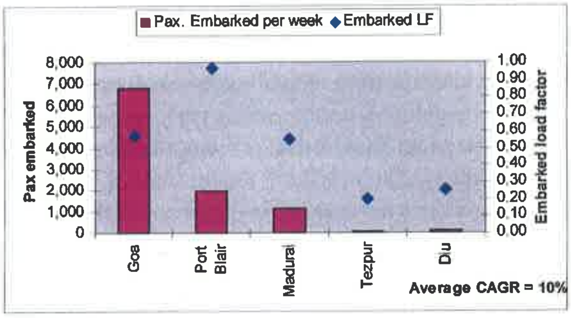

Fig.5 Passengers Embarked and ELF for Class C Cities

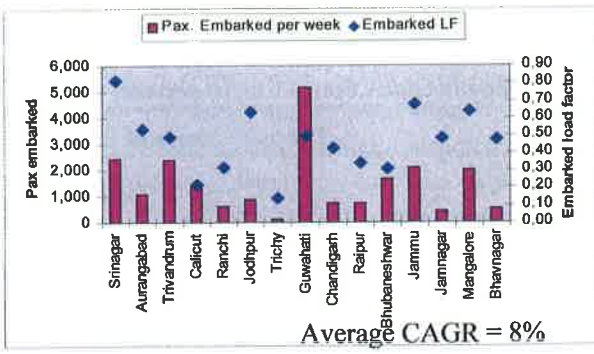

Fig.6 Passengers Embarked and ELF for Class D Cities

where airports are available and infrastructure has been provided, the airlines have commenced operations (2, 4). Analysis of the data indicates that there are 14 cities in the North, 17 in the South, 7 in East, 16 in the West and 11 in the North East region that have air connectivity.

Figures 2 to 6 shows the measure of total passengers embarking and disembarking by the aircraft movements from a city and this information can provide indicative system load factor of each of the metro/city/town. It is clear from figures that certain cities like Chandigarh, Port Blair, Bhopal, Rajkot, Jodhpur, Raipur, Aijwal, Jorhat, Dimapur, Diu show higher CAGR (10 percent and above during 1996-2004), while there appears to be a decline in CAGR in certain cities. All major metros show an aggregate CAGR of 3 to 5 percent, whereas it is around 2 to 3, 5, 7, 10 percent for metros, class B. C and D cities respectively.

It is clear from these figures that these gross embarked load factors (ELFs) indicate that there is a need to rationalize and introduce the right type of aircraft from an origin city to other destinations. An analysis of embarked load factors clearly indicate that there are a number of cities where the ELFs vary from 20 percent on some routes to more than 70 percent on other routes. In the above study it is observed that the load factors are below 50 percent, in majority of the class B to D (tier-II to IV) cities. This strongly indicates that there is a need to rationalize and use small aircraft, because most of the fleet presently operated are with B-737, A-320, ATR aircraft. Table-4 enumerates the fleet composition presently being deployed on feeder routes. The feeder services in North East are based on route dispersal guidelines and the operations are not purely governed by local requirement or economics. Sometimes these obligations are traded between airlines. Going by the gross load factors, half of the presently connected cities may not justify the use of bigger aircraft. Hence, feeder operations in India need a re-look in terms of fleet composition and size, route network, frequencies and fare structure. In this paper, issues related to fleet composition, flight frequencies, load factors are incorporated in the analysis.

Table-4 : Present Aircraft Fleet Composition on Feeder Routes

Aircraft Type	Seating Capacity
ATR - 42	48 Seats
ATR - 72	62 Seats
B - 737	119 to 168 Seats
AB - 320	146 Seats
CRJ - 200	50 Seats
ERJ - 145	50 Seats

Modal Split in Inter City Transport in India

The extent of transport network reflects a multiplier effect in the economic development of any country and India is no exception to this. Railways, Roadways, and Airlines are the main mode of passenger transport in India.

Roadways are generally preferred for short travel, while for long distance travel (range of 500 km and more), the preferred modes nowadays are railways and airlines. As per the latest data, the typical modal split in intercity travel in India in terms of passengers carried are 61 percent by railways, 37 percent by roadways and 2 percent by airlines. The national highways (NHs) are considered to be the backbone of transport network in India and probably a competing mode to air travel apart from rail, especially for short haul travel. Though NHs constitutes only 2 percent of total road length, but it carries around 40 percent of total road traffic. This indirectly indicates that the NH network is not developing at par with the growth of traffic expected on it. With respect to rail (track) density, Northern region, West Bengal, and Tamil Nadu accounts for higher proportion (5, 6).

Similarly, the comparison of modal split between upper class rail and air transport in India shows that the figures are favourable to airlines, which accounts for 57 percent while upper class rail stands at 43 percent. If we look at the long-term growth of intercity transport for the period 1996-2004 (Fig.7), the airlines and railways grew

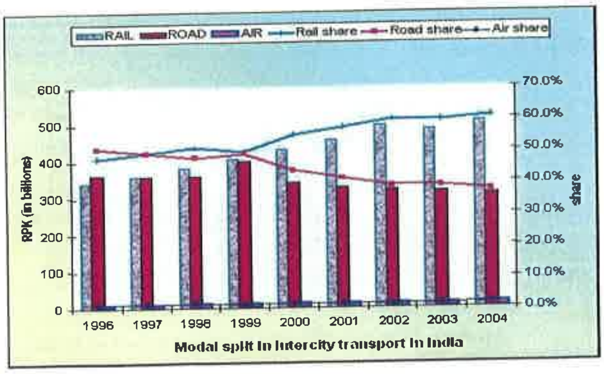

Fig.7 Long-term Trends in Growth of Intercity Transport (pax-km in mn)

by 7 and 5 percent (CAGR) respectively, while the roadways experienced a negative growth (-2%). The share of intercity traffic among modes for the same period indicates the share of railways has increased to 61 percent from 48 percent, wheras the airlines share has marginally increased from 1.2 percent in 1996 to 1.7 percent in 2004.

Impact of Low Cost Carriers (LCC) on Upper Class Rail Travel Pattern

The time series data on the growth trends in intercity rail (upper class) and air transport shown in Fig.8 clearly indicates that the introduction of Shatabti and Rajdhani services in 1990s might have influenced the price sensitive travellers towards these services thereby increasing the share of upper class rail travel. The reverse trend has been observed during 2003 thus marking the start of LCCs in India coupled with the price war among them.

Estimation of Passenger and Aircraft Demand

Passenger Traffic on Existing Feeder Routes

The total traffic on feeder routes is arrived at by the addition of rail passengers willing to shift to air travel to the present air traffic on the feeder routes. The expected shift from rail travel is estimated based on price sensitivity curves (5) for each region developed as per the study conducted in 1999-2000 as shown in Fig.9. The estimated total traffic (for some typical routes) for the year 2004 is shown in Table-5.

Considering the recent price war, the shift from rail to air travel would likely increase further since the premium of air travel over rail travel will decrease with decline in air travel prices. A fresh passengers survey may be carried out to ascertain the willingness to shift to air travel in the

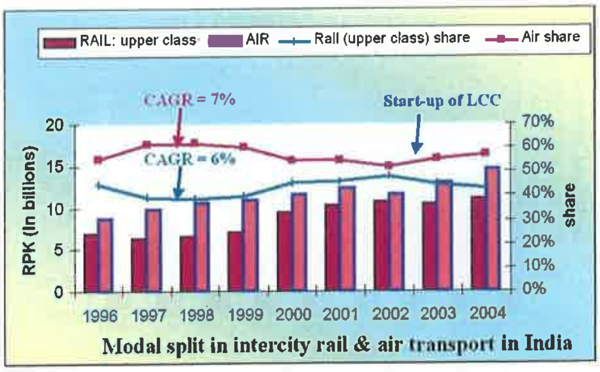

Fig.8 Passenger Traffic Carried by Upper Class Rail and Air Transport

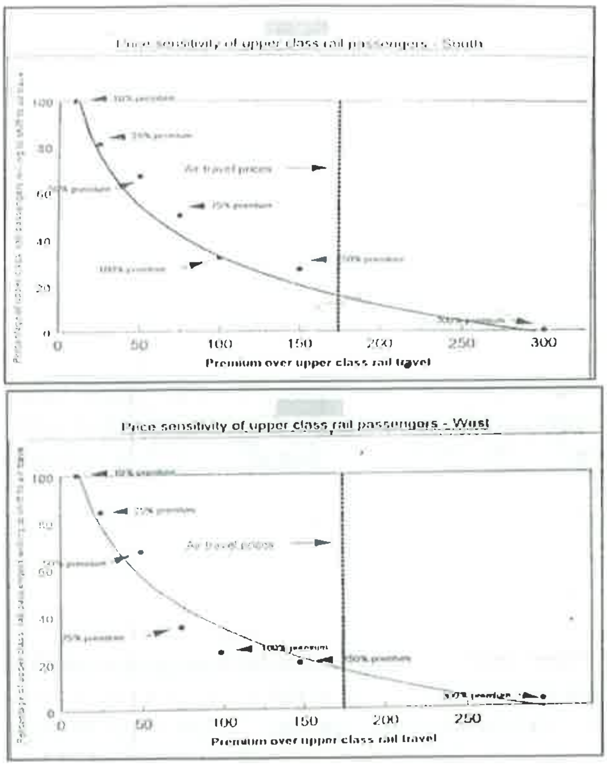

Fig.9(a) Price Sensitivity of Upper Class Rail Passengers (South and West Region) (Source : 5)

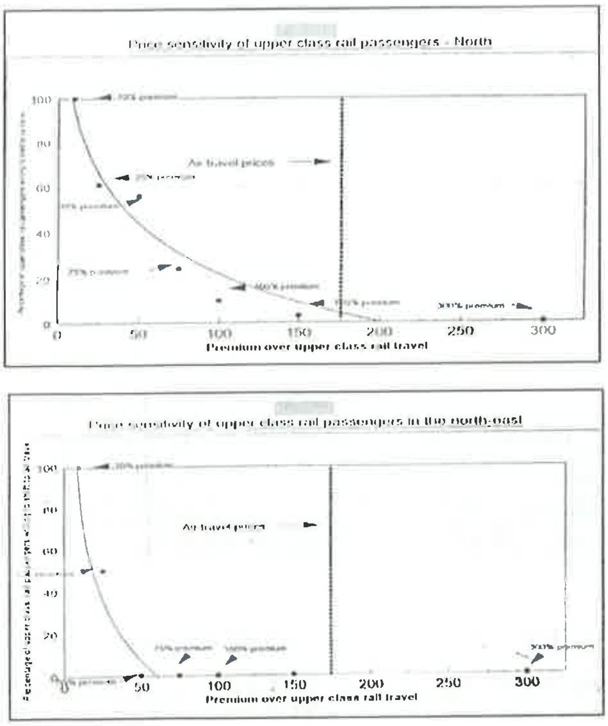

Fig.9(b) Price Sensitivity of Upper Class Rail Passengers (North and North East Region) (Source : 5)

Table-5 : Estimated Total Passengers on Some Typical (Existing) Feeder Routes (2004)

Sl. No.	CP. No.	Region	Origin	Destination	Present Air Pax. Traffic (per week) (1)	No. of Rail Pax. willing to Shift to Air Travel (2)	Total Air Pax. Traffic (per week) (1+2)
1	15	N	Delhi (N)	Amritsar	66	3	69
2	17	N	Delhi (N)	Jaipur	730	14	744
3	21	N	Delhi (N)	Lucknow	1041	4	1045
4	46	S	Bangalore (S)	Coimbatore	490	10	500
5	52	S	Chennai (S)	Coimbatore	443	26	469
6	53	S	Chennai (S)	Madurai	295	86	381
7	54	S	Chennai (S)	Trichy	117	151	268
8	55	S	Hyderabad (S)	Nagpur	215	29	244
9	56	S	Hyderabad (S)	Tirupati	193	40	233
10	61	W	Ahmedabad (W)	Vadodara	159	26	185
11	72	W	Mumbai (W)	Rajkot	1228	9	1237
12	74	W	Nagpur (W)	Raipur	18	5	23

changed scenario due to increase in disposable income levels etc.

Determination of Optimum Aircraft Size

An approach for determining the suitable aircraft size for feeder routes is arrived at from the basic principles of airline business (15, 16) and thus obtaining the eqn (1).

Step 1 :

$$LF = \frac{P}{AS \times F} \rightarrow AS_{ijr} = \frac{P_{ijr}}{F_{ijr} \times LF_{ijr}} \quad (1)$$

Step 2 :

Criteria for Load factors and Flight frequencies (lower and upper bounds)

$$0.5 \leq LF_{ijr} \leq 1.00 \quad (1a)$$

$$0.5 \leq \left[LF_{ijr} = \frac{P_{ijr}}{AS_{ijr} \times F_{ijr}} \right] \leq 1.00 \quad (1b)$$

$1 \leq F_{ijr} \leq F_{max}$, F_{max} = 14 to 42 depending on aircraft type and year (1c)

Where,

AS_{ijr} = Capacity of the aircraft deployed on city pair 'i-j' on route 'r' (available seats)

P_{ijr} = Passenger traffic between city 'i' and 'j' on route 'r' per week

F_{ijr} = Frequency of flights between city 'i' and 'j' on route 'r' per week

LF_{ijr} = Load factor on city pair 'i-j' on route 'r'

It is assumed that 2 flights per day (per direction) and a load factor of 80 percent as a preliminary step in determining the aircraft size based on the passenger demand expected on the routes. The analysis shows that the aircraft size suitable for the existing traffic pattern varies from 4 seater to 100 seater (high density metro to metro feeder routes like Chennai- Bangalore etc. are not considered). As this is a wide range, the aircraft size which suits the following criteria are being selected as:

- There should be 2 flights per day (14 flights per week/direction) subjected to minimum and maximum load factors (assumed as 50 percent and 100 percent respectively).
- If the load factor falls below 50%, the frequencies are kept on weekly basis varying from 1 flight per week to 7 flights per week per direction).

- If the load factor exceeds 100% with 2 flights per day, then the next suitable higher size aircraft, which suits again the above load factor and frequency criteria, has been chosen.

In addition to this, the following assumptions were made with reference to the flight frequencies for various types of aircraft on year-wise (long term) basis.

$1 \leq F_{ijr} \leq 14$, for 10-20, 30-50, 70 seater up to the year 2010 (i.e. frequency varies from 1 flight to 14 flights per week per direction).

$1 \leq F_{ijr} \leq 28$, for 100 seater up to the year 2010 (i.e. frequency varies from 1 flight to 28 flights per week per direction).

$1 \leq F_{ijr} \leq 28$, (for 10-20, 30-50, 70 seater from the year 2010 onwards (i.e. frequency varies from 1 flight to 28 flights per week per direction).

$1 \leq F_{ijr} \leq 42$, for 100 seater from the year 2010 onwards (i.e. frequency varies from 1 flight to 42 flights per week per direction).

Based on the traffic pattern of 2005, the rationalization of aircraft fleet mix arrived for various levels of passenger demand are shown in Fig.10.

The estimated total passenger demand and revenue passenger kilometers (RPKs) for existing and new feeder routes (76 existing and 57 new routes in all regions out of these Chennai-Bangalore sector has been excluded) for 2005 are presented in Table-6. The region-wise estimations in respect of passenger demand, RPKs and the share

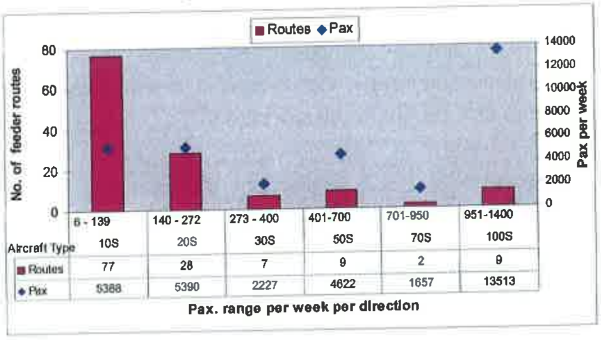

Fig.10 Determination of Aircraft Size for Various Levels of Passenger Demand

of RPKs (i.e., for each region/hub and aircraft category) for the year 2004 is presented in Annexure I (a).

Estimation of Fleet Requirement: Aircraft Demand

Based on the growth trends of the past five years data and the overall RPKs estimated in an earlier market survey (5), the forecast of RPKs are arrived. The trend based on the actual RPKs (2000-2004) data and the estimated RPKs (1998-2008) of earlier market survey is shown in Fig.11. The steps followed in estimation of aircraft demand as shown in Table-7.

The number of aircraft required to fulfill the feeder RPKs is estimated for the following assumed hours of aircraft utilization/operation, average block speed and load factors are shown in Table-8. The region-wise estimation of RPKs performed by each aircraft type was presented in Annexure II.

The region-wise splits in load factors along with the total number of services for the year 2004 are shown in

Table-6 : Estimated Passengers and RPKs for all Feeder Routes : All Regions (Year 2005)

Sl. No.	Aircraft Type	Pax. per week (per direction)	RPK per week (per direction)
1	10S	5388	1,717,084
2	20S	5390	1,693,553
3	30S	2227	765,506
4	50S	4622	1,753,849
5	70S	1657	499,126
6	100S	13513	5,116,662
	Total	**32797**	**11,545,780**

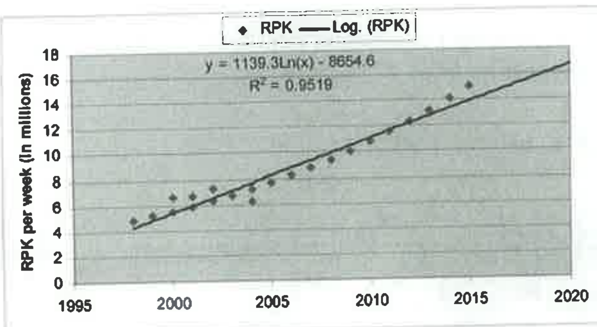

Fig.11 Forecase of RPKs upto 2020 (for existing feeder routes)

Annexure I a. Estimated Passenger Demand and RPKs (Region/ Hub wise) for Existing & Potential Feeder Routes (Year 2005)

	10S		20S		30S		50S		70S		100S		Total		RPK
Hub	Pax.	RPKs	Pax.	RPKs	Pax.	RPKs	Pax.	RPKs	Pax.	RPKs	Pax.	RPKs	Pax.	RPKs	share%
E	631	215,798	648	290,798	1,006	405,917	0	0	0	0	1,211	381,314	3,496	1,293,827	11.21
	Share%	16.68		22.48		31.37		0.00		0.00		29.47		100.00	
N	955	311,180	791	198,200	934	259,048	0	0	789	181,387	5,934	3,026,141	9,403	3,975,956	34.44
	Share%	7.83		4.98		6.52		0.00		4.56		76.11		100.00	
NE	494	136,554	1,195	308,449	287	100,541	654	202,248	0	0	0	0	2,630	747,792	6.48
	Share%	18.26		41.25		13.45		27.05		0.00		0.00		100.00	
S	1,894	605,891	1,597	439,274	0	0	2,294	755,318	868	317,739	0	0	6,653	2,118,222	18.35
	Share%	28.60		20.74		0.00		35.66		15.00		0.00		100.00	
W	1,414	447,661	1,159	456,832	0	0	1,654	796,283	0	0	6,368	1,709,207	10,595	3,409,983	29.53
	Share%	13.13		13.40		0.00		23.35		0.00		50.12		100.00	
	5,388	1,717,084	5,390	1,693,553	2,227	765,506	4,602	1,753,849	1,657	499,126	13,513	5,116,662	32,777	11,545,780	100.00

Annexure I b. Estimated Frequencies Per Week and Average Load Factors (Region/ Hub wise) for Feeder Routes (Year 2005)

	10S		20S		30S		50S		70S		100S		Total	
	Freq.	LF	Freq.	LF	Freq.	LF	Freq.	LF	Freq.	LF	Freq.	LF	Freq.	Avg. LF
E	96	0.64	42	0.77	42	0.80	0	-	0	-	14	0.86	194	0.77
N	143	0.64	70	0.56	42	0.74	0	-	14	0.80	77	0.77	346	0.70
NE	64	0.75	84	0.71	14	0.68	14	0.96	0	-	0	-	176	0.78
S	270	0.71	112	0.71	0	-	63	0.74	14	0.89	0	-	459	0.76
W	198	0.71	84	0.69	0	-	42	0.79	0	-	77	0.84	401	0.76
	771	0.69	392	0.69	98	0.74	119	0.83	28	0.85	168	0.82	1,576	0.77

Annexure I c. Average RPK Share (Region/ Hub wise) for Feeder Routes Based on 6% CAGR : 2005-2020

Hub	Aircraft Size & Year 2005							Region	Aircraft Size & Year 2010						
	10S	20S	30S	50S	70S	100S	share%		10S	20S	30S	50S	70S	100S	share %
E	16.68	22.48	31.37	0.00	0.00	29.47	11.21	E	16.68	9.94	17.17	26.74	0.00	29.47	11.26
N	7.83	4.98	6.52	0.00	4.56	76.11	34.44	N	6.11	6.61	1.81	4.66	0.00	80.82	34.83
NE	18.26	41.25	13.35	27.05	0.00	0.00	6.48	NE	8.78	34.60	29.57	0.00	0.00	0.00	6.50
S	28.60	20.74	0.00	35.66	15.00	0.00	18.35	S	23.49	15.40	16.13	21.92	0.00	23.06	17.76
W	13.13	13.40	0.00	23.35	0.00	50.12	27.25	W	10.49	9.43	6.61	6.91	16.44	50.12	29.65
							100.00							Total	100.00
Hub	Aircraft Size & Year 2015							Region	Aircraft Size & Year 2020						
	10S	20S	30S	50S	70S	100S	share%		10S	20S	30S	50S	70S	100S	share %
E	16.68	22.47	31.38	0.00	0.00	29.47	11.21	E	16.68	9.94	30.09	13.81	0.00	29.47	13.57
N	9.12	5.51	4.69	0.00	17.09	63.58	34.44	N	9.30	8.70	9.15	0.00	6.41	66.44	[illegible]
NE	18.26	54.69	0.00	27.05	0.00	0.00	6.48	NE	8.78	43.92	20.25	0.00	27.05	0.00	7.84
S	30.72	22.37	0.00	31.91	15.00	0.00	18.34	S	25.43	12.10	15.56	31.91	0.00	15.00	22.22
W	13.13	9.42	0.00	27.33	0.00	50.12	29.54	W	14.06	16.17	0.00	21.31	15.32	33.13	[illegible]
						Total	[illegible]							Total	100.00

Annexure I d. Average Load Factor (region/ hub wise) for feeder routes based on 6% CAGR: 2005-20

Hub	Aircraft Size & Year 2005							Region	Aircraft Size & Year 2010						
Hub	10S	20S	30S	50S	70S	100S	Avg. LF	Region	10S	20S	30S	50S	70S	100S	Avg. LF
E	0.64	0.77	0.80	-	-	0.86	0.77	E	0.85	0.90	0.91	0.67	-	0.77	0.82
N	0.64	0.56	0.74	-	0.80	0.77	0.70	N	0.81	0.70	0.94	0.61	-	0.86	0.78
NE	0.75	0.71	0.68	0.96	-	-	0.78	NE	0.70	0.81	0.82	-	0.92	-	0.81
S	0.71	0.71	-	0.74	0.89	-	0.76	S	0.78	0.69	0.84	0.80	-	0.69	0.76
W	0.71	0.69	-	0.79	-	0.84	0.76	W	0.81	0.75	0.77	0.92	0.80	0.86	0.82
Avg.	0.69	0.69	0.74	0.83	0.85	0.82	0.77	Avg. LF	0.79	0.77	0.86	0.75	0.86	0.80	0.80
	Aircraft Size & Year 2015								Aircraft Size & Year 2020						
Hub	10S	20S	30S	50S	70S	100S	Avg. LF	Region	10S	20S	30S	50S	70S	100S	Avg. LF
E	0.79	0.82	0.87	-	-	0.77	0.81	E	0.80	0.80	0.87	0.62	-	1.00	0.82
N	0.71	0.87	0.91	-	0.94	0.83	0.85	N	0.78	0.83	0.89	-	0.96	0.93	0.88
NE	0.77	0.83	-	0.86	-	-	0.82	NE	0.74	0.88	0.77	-	0.82	-	0.80
S	0.83	0.81	-	0.86	0.79	-	0.82	S	0.81	0.79	0.75	0.86	-	0.74	0.79
W	0.76	0.83	-	0.80	-	0.87	0.82	W	0.77	0.83	-	0.77	0.80	0.92	0.82
Avg.	0.77	0.83	0.89	0.84	0.87	0.82	0.84	Avg. LF	0.78	0.83	0.82	0.75	0.86	0.90	0.82

RPK = Revenue Passenger Kilometres, Pax. = Passengers, Freq. = Flight Frequency, Avg.LF = Average Load Factor, 10S = 10 Seater

E = East (Kolkata), N = North (Delhi), NE = North East (Guwahati), S = South (Chennai/ Bangalore/ Hyderabad), W = West (Mumbai)

Table-7 : The Approach Followed for Estimation of Aircraft Demand

Step	Description	Formula
Step 1	Determination of average load factor for predicting the number of each aircraft type	$LF_{rq} = \dfrac{\sum \dfrac{P_{ijrq}}{AS_{ijrq} \times F_{ijrq}}}{C}$
Step 2	Estimation of RPKs performed by an aircraft	$RPK_{rq} = AS_{rq} \times LF_{rq} \times V_q \times U_q$
Step 3	Estimation of number of aircraft	$N_{rq} = \dfrac{\sum_c RPK_{ijrq}}{RPK_{rq}}$

Where,

LF_{rq}	= Load factor on route 'r' for aircraft type 'q'
P_{ijrq}	= Passenger traffic between city 'i' and 'j' on route 'r' per week for aircraft 'q'
AS_{ijrq}	= Capacity of 'q' type aircraft on city pair 'i-j' on route 'r' (available seats)
F_{ijrq}	= Frequency of flights per week of 'q' type aircraft for city pair 'i-j' on route 'r'
C	= Number of routes/city pairs
RKP_{rq}	= Revenue passenger Km on route 'r' for aircraft type 'q' per week
AS_{rq}	= Capacity of 'q' type aircraft on route 'r' (available seats)
V_q	= Block speed of aircraft type 'q'
U_q	= Utilization of aircraft type 'q'
N_q	= Number of aircraft type 'q'

Table-8 : Estimation of RPKs Performed by an Aircraft (Year 2005)

AS	Avg.LF (all Regions)	Average Block Speed (Kmph)	Average Utilization (per week)	RPKs (per week)
10	0.69	400	49	135,240
20	0.69	350	49	236,670
30	0.74	400	49	435,120
50	0.83	400	49	813,400
70	0.85	350	49	1,020,425
100	0.82	500	49	2,009,000

Annexure II. Estimation of RPKs Performed by an Aircraft					
Aircraft size	Region	Avg. LF (2005)	Avg. block speed (kmph)	Utilisation (hrs/ week)	RPKs/ week
10	East	0.64	400	49	125,440
	North	0.64	400	49	125,440
	North east	0.75	400	49	147,000
	South	0.71	400	49	139,160
	West	0.71	400	49	139,160
	Avg.	**0.69**	**400**	**49**	**135,240**
20	East	0.77	350	49	264,110
	North	0.56	350	49	192,080
	North east	0.71	350	49	243,530
	South	0.71	350	49	243,530
	West	0.69	350	49	236,670
	Avg.	**0.69**	**350**	**49**	**236,670**
30	East	0.80	400	49	470,400
	North	0.74	400	49	435,120
	North east	0.68	400	49	399,840
	South	-	-	-	-
	West	-	-	-	-
	Avg.	**0.74**	**400**	**49**	**435,120**
50	East	-	-	-	-
	North	-	-	-	-
	North east	0.96	400	49	940,800
	South	0.74	400	49	725,200
	West	0.79	400	49	774,200
	Avg.	**0.83**	**400**	**49**	**813,400**
70	East	-	-	-	-
	North	0.80	350	49	960,400
	North east	-	-	-	-
	South	0.89	350	49	1,068,445
	West	-	-	-	-
	Avg.	**0.85**	**350**	**49**	**1,020,425**
100	East	0.86	500	49	2,107,000
	North	0.77	500	49	1,886,500
	North east	-	-	-	-
	South	-	-	-	-
	West	0.84	500	49	2,058,000
	Avg.	**0.82**	**500**	**49**	**2,009,000**

Annexure I (b). To estimate the future demand in RPKs for each region/hub (viz., East, North, North East, South, and West) and aircraft category (ranging from 10 to 100 seater), two things are important :

- RPKs associated in each region and the distribution of these region-wise RPKs to each aircraft category and
- Region-wise average load factors of each aircraft type.

For this purpose, the region-wise average share in RPKs for the period (2005-2020) are computed and again these region-wise RPKs are split for each aircraft type as per their share in each region. These average yearly (during 2005-2020) shares in RPKs and load factors as presented in Annexure I (c) and Annexure I (d) respectively are used to estimate the fleet requirement upto the year 2020. A simplified approach/ measure is used to determine the aircraft demand: estimated RPKs on each region for each aircraft type divided by the RPKs that an aircraft can perform. The region/hub-wise estimated aircraft demand upto the year 2020 for existing feeder routes is presented in Table-10.

Passenger Traffic on Potential City Pairs

Based on the previous studies (5, 7) and the priority associated with reference to business, tourism, and industry, a list of potential cities are presented in Table-9.

Determination of suitable aircraft size (same methodology as in the case of existing feeder routes) for the

Table-9 : Potential Cities for Feeder Air Connectivity

States	Sl. No.	City	States	Sl. No.	City
Madhya Pradesh, Uttar Pradesh, Uttaranchal	1	Jabalpur	Andhra Pradesh, Karnataka	23	Mysore
	2	Gwalior		24	Hassan
	3	Allahabad		25	Belgaum
	4	Kanpur		26	Hubli
	5	Dehradun		27	Gulbarga
	6	Nainital/Moradabad		28	Bellary
Jamu and Kashmir, Himachal Pradesh, Punjab	7	Udhampur		29	Shimoga
	8	Shimla		30	Vijayawada
	9	Patiala		31	Puttaparthy
	10	Ludhiana		32	Rajamundry
	11	Jallandar		33	Kadapa
Mahrashtra	12	Nasik	West Bengal, Orissa, Bihar, Jharkand, Chattisgarh	34	Darjeeling
	13	Kolhapur		35	Rourkela
	14	Ahmednagar		36	Jaypur/Koraput
Gujarat, Rajasthan	15	Surat		37	Gaya
	16	Kesod		38	Dhanbad
	17	Kota		39	Jemshedpur
	18	Jaisalmer	North East	40	Shillong
	19	Ajmer		41	Gangtok
	20	Bikaner		42	Itanagar
Kerala, Tamil Nadu	21	Salem		43	Pasighat
	22	Pondichery/Tuticorn			

potential city pairs is based on the estimated passenger traffic of market survey conducted in 1998-1999 (9, 26). The RPKs has been forecasted based on the estimated data of 2000-2008. The forecast of RPKs for potential city pairs is shown in Fig.12.

The estimation of RPKs and fleet requirement are arrived at based on the methodology discussed in earlier sections. The region/hub-wise estimated RPKs for a type of aircraft fleet mix and the fleet requirement for potential city pairs are presented Table-10.

Total Aircraft Fleet Requirement for Existing and Potential Feeder Routes

The demand estimation of aircraft has been carried out for feeder routes based on:

Table-10 : Estimated Aircraft Fleet Size for Existing (76) and Potential (57) Feeder Routes (based on 6% CAGR Growth Trend of Estimated RPKs)

Sl. No.	Year	Region/Hub	Aircraft Size					
			RPK	10-20S	30-50S	70-100S	> 100S	Total
1	2005	E	1,293,729	6	2	2	-	10
		N	3,975,956	8	2	6	-	16
		NE	747,792	6	4	0	-	10
		S	2,118,222	14	2	2	-	18
		W	3,409,983	12	2	2	-	16
		Total	**11,545,682**	**46**	**12**	**12**	-	**70**
2	2010	E	1,731,302	6	4	2	-	12
		N	5,360,730	8	4	4	-	16
		NE	1,000,714	6	2	2	-	10
		S	2,733,658	14	4	2	-	20
		W	4,563,568	10	4	4	-	18
		Total	**15,389,972**	**44**	**18**	**14**	-	**76**
2	2015	E	2,316,871	10	4	2	-	16
		N	7,120,332	14	2	8	-	24
		NE	1,339,181	10	2	0	-	12
		S	3,792,886	22	4	2	-	28
		W	6,107,495	16	4	4	-	24
		Total	**20,676,765**	**72**	**16**	**16**	-	**104**
3	2020	E	3,100,497	12	6	2	-	20
		N	9,528,612	12	4	6	2	24
		NE	1,792,127	8	2	2	-	12
		S	5,075,651	24	8	2	-	34
		W	8,172,788	20	4	4	2	30
		Total	**27,669,775**	**76**	**24**	**16**	**4**	**120**

Region/Hub

E = East (Kolkata), N = North (Delhi), NE = North East (Guwahati)

S = South (Chennai/Bangalore/Hyderabad), W = West (Mumbai)

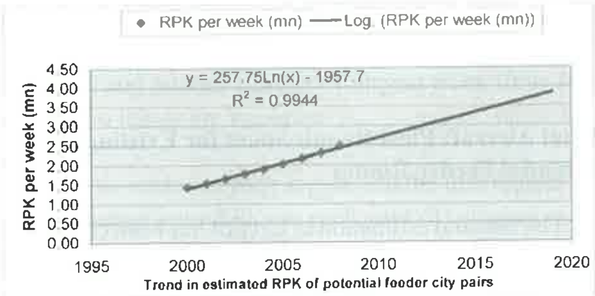

Fig.12 Forecast of RPKs for Potential City Pairs Based on Estimated RPKs

- Rationalization of aircraft fleet based on present air traffic and upper class rail traffic willing to shift to air, and
- Future growth of traffic in tier III and tier IV cities, which are potential locations for feeder airline connectivity.

The total fleet requirement based on the estimated and forecasted traffic upto 2020 as detailed in earlier sections are also presented in Table-10. The 2005 fleet requirements for feeder routes are estimated to be 70 aircraft (46 aircraft in the category of 10-20 seater, 12 aircraft in 30-50 seater category, and 12 aircraft in 70-100 seater category). The estimated cumulative demand for aircraft is 76 in the year 2009-2010, and 120 in the year 2019-2020 (Table-10). Based on the estimated and forecasted RPKs data, the CAGR during the period 2004-2020 stands at 6 percent. But, considering the sharp growth of air travel in recent years, the future air traffic is expected to grow at high rate of increase. Hence, an attempt has also been made in the next section to forecast the fleet demand for feeder routes at higher growth per annum.

Future

The sharp increase in air travel over the last few years indicate that air travel is surging ahead at 22 to 26 percent growth per annum. The factors attributed to this are:

- Significant shift of middle class travellers from railways to LCC.
- Airfares are slightly higher than A/C II-tier rail fares.
- India posted a high Gross Domestic Product (GDP) annual growth rate close to 8 percent.
- Outsourcing of business processes to India and export of software and services resulted in the young middle class suddenly having considerable spare income.

Based on estimated RPKs for existing and potential city pairs up to 2020, the CAGR (2004- 2020) is around 6 percent. During the first three years of tenth five year plan (2002-2007), the air transport sector has grown at an average annual growth rate (AAGR) of 7 percent, against the plan estimate of 5 percent. In 2004-2005, air transport witnessed a growth of 24 percent convincing many in the Govt. that the AAGR of 16 percent is achievable by 2010. Now the experts forecast that the high rate of increase in air travel is likely to continue (8, 9). Hence, a sensitivity analysis has been carried out at 12 percent, 16 percent and 24 percent traffic growth rate per annum and the results pertaining to estimated total RPKs and the fleet required are shown in Annexure III. The total aircraft (10 to 100 seater category) demand by the year 2020 are 144, 154, and 164 at 12, 16, and 24 percent levels of traffic growth respectively.

Future growth in air traffic will be fuelled by feeder sector, as the hinterland opens up industry, service and tourism. The world has recognized that India is going to be an economic power in the 21st century. This will create a favourable environment for multinational companies (MNCs) to look forward to India to invest in joint venture (JV) projects apart from the outsource business partners (OBP) regime. The recent move by the tourism organizations to provide 'package tourism' will have potential attraction to domestic as well as foreign tourists. These will certainly enhance the propensity to travel to untapped economic and tourist destinations. Migration from rail to air is likely to be on the increase due to high disposable income, aggressive reduction in airfares in a competitive environment and comfort, convenience, and lesser travel time associated with air transport. Feeder services can augment better air connectivity in terrains because it is cheaper to build an airstrip than to provide surface connectivity.

Conclusion

The number of feeder routes at present is 76 with another 43 cities as potential locations for air connectivity. Considering the current increase in passenger traffic and the future growth potential of tier III and tier IV cities, there is need for creation of feeder air network connectivity in India. Two simplified approaches are used in this paper to determine a suitable aircraft size as well as the

Annexure III. Estimated Total Aircraft Demand for Existing (76) and Potential (57) Feeder Routes at Various Levels of Traffic Growth (Base Year 2006)

S.No	Year	Hub	Aircraft Demand @12% Growth						Aircraft Demand @16% Growth						Aircraft Demand @24% Growth					
			RPK	10-20S	30-50S	70-100S	>100S	Total	RPK	10-20S	30-50S	70-100S	>100S	Total	RPK	10-20S	30-50S	70-100S	>100S	Total
1	2005	E	1,293,729	6	2	2	-	10	1,293,729	6	2	2	-	10	1,293,729	6	2	2	-	10
		N	3,975,956	8	2	6	-	16	3,975,956	8	2	6	-	16	3,975,956	8	2	6	-	16
		NE	747,792	6	4	0	-	10	747,792	6	4	0	-	10	747,792	6	4	0	-	10
		S	2,118,222	14	2	2	-	18	317,739	14	2	2	-	18	317,739	14	2	2	-	18
		W	3,409,983	12	2	2	-	16	3,409,983	12	2	2	-	16	3,409,983	12	2	2	-	16
	Total		11,645,682	46	12	12	-	70	9,745,199	46	12	12	-	70	9,745,199	46	12	12	-	70
2	2010	E	2,157,849	6	6	2	-	14	2,440,330	6	6	2	-	14	3,242,172	6	2	6	-	14
		N	6,631,620	8	4	6	-	18	7,630,965	10	4	8	-	22	9,964,012	8	4	6	4	22
		NE	1,247,264	4	4	2	-	10	1,435,220	4	4	2	-	10	1,874,015	4	4	4	-	12
		S	3,531,725	12	6	4	-	22	4,020,420	12	4	4	-	20	5,307,733	12	6	6	-	24
		W	5,687,396	10	4	6	-	20	6,545,127	10	4	6	2	22	8,545,972	10	6	4	2	22
	Total		19,265,854	40	24	20	-	84	22,072,062	42	22	22	2	88	28,933,904	40	22	26	6	94
3	2015	E	3,802,868	8	8	0	2	18	5,215,201	10	8	2	2	20	9,504,830	4	6	8	2	20
		N	11,687,180	16	6	4	4	30	16,027,635	14	4	6	6	30	29,210,748	12	8	4	8	32
		NE	2,198,107	8	4	2	-	14	3,014,453	6	8	2	-	16	5,493,912	4	6	6	2	18
		S	2,810,978	20	8	6	-	34	8,537,230	20	8	6	-	34	15,559,648	12	16	12	2	42
		W	10,024,100	20	4	8	2	34	13,747,041	16	10	4	4	34	25,054,072	10	14	8	8	40
	Total		30,623,233	72	30	20	8	130	46,541,660	66	38	20	12	134	84,823,210	42	60	38	22	152
4	2020	E	6,701,955	10	2	6	2	20	10,953,703	4	6	10	2	22	27,864,596	4	2	10	8	24
		N	20,596,803	14	6	6	8	34	33,663,507	12	6	8	12	38	65,634,962	6	8	10	16	40
		NE	3,610,239	4	6	4	-	14	6,331,382	4	4	6	2	16	16,106,091	4	2	8	6	20
		S	10,970,972	20	10	6	2	38	17,932,121	6	18	10	4	38	45,614,307	2	4	20	12	38
		W	17,666,177	18	10	6	4	38	28,873,691	10	12	10	8	40	65,054,687	4	8	14	16	42
	Total		59,546,146	66	34	28	16	144	97,764,404	36	46	44	28	154	240,274,643	20	24	62	58	164

Region/Hub:
E = East (Kolkata), N = North (Delhi), NE = North East (Guwahati)
S = South (Chennai/ Bangalore/ Hyderabad), W = West (Mumbai)
RPK = Revenue Passenger Kilometers, 10-20S = 10 & 20 Seater Capacity

demand for such aircraft types. Air traffic has registered unprecedented growth over the last 2 to 3 years. The advent of low cost carriers (LCCs) has moved traffic from upper class rail to air. The price sensitivity curves were developed in 1998-99 and accordingly the shift from premium rail to air was estimated, but the current situation is quite different due to significant increase in the middle class with high disposable income. Feeder traffic is growing at a much slower rate but steady rate of approximately at 5 percent. It is expected that the future growth will be led by feeder sector thereby creating tremendous opportunities for economically viable operations. To sustain the traffic growth, the rational selection of route, passenger friendly frequency with a mix of aircraft size viz., 10-20 seater, 30-50 seater, and 70-100 seater are to be taken into account. The aircraft type is likely to be turbo prop due to its better specific fuel consumption (SFC), as prices of aviation turbine fuel (ATF) will continue to fluctuate upwards. The demand for passenger traffic, suitable aircraft size and expected demand for each aircraft type was arrived at based on a simplified approach and macroscopic aggregate measure. The author believes that this approach will help for assessing alternative fleet scenarios and possibly reflect a quick method of estimating passenger traffic, aircraft and fleet size for serving feeder air network in India.

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